Available online at www.sciencedirect.com

ScienceDirect

Procedia - Social and Behavioral Sciences 224 (2016) 221 – 229

Procedia
Social and Behavioral Sciences

6th International Research Symposium in Service Management, IRSSM-6 2015, 11-15 August 2015, UiTM Sarawak, Kuching, Malaysia

Are Shares More Volatile during the Global Financial Crisis?

Azilawati Banchit[a,]*, Sazali Abidin[b], Junqi Wu[c]

[a] *Faculty of Business Management, Universiti Teknologi MARA, 94300, Kota Samarahan, Sarawak, Malaysia*
[b, c] *Department of Finance, Waikato Management School, University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand*

Abstract

This research empirically identifies price jump phenomenon of heavily traded New Zealand shares focusing on the period of GFC2008. Specifically, this paper confirms the hypothesis that the price jump behaviour does not change during the recent financial turbulence. To achieve this goal, the study uses realized trades for 10 shares and one ETF (Exchange Trade Fund) from the Yahoo Finance & NZX50 database. Data selected were from January 2008 to the end of July 2009, as the GFC2008 is generally accepted to begin with the plunge of Lehman Brothers shares on September 9, 2008. The study adopts three models to examine the price jump phenomenon. The results reveal an increasing overall volatility during the crisis; however, the null hypothesis made cannot be rejected, which means there was no change for the behaviour of price jump in the data during the financial crisis. Overall, it implies that the uncertainty among NZ stock market has increased during the crisis but the structure of the uncertainty remains the same.

Peer-review under responsibility of the Universiti Teknologi MARA Sarawak

Keywords: stock price volatility; market behaviour; global financial crisis

1. Introduction

The behaviour of stock prices in the financial markets is usually unpredictable even during the non-crisis period. This uncertainty means that the unpredictability of financial instruments follows a random walk in the price process. Noise movement does tamper with the price process and this is known as market volatility (Novotny, 2010).

* Corresponding author. Tel.: +6-082-677-500.
E-mail address: azila@sarawak.uitm.edu.my

Peer-review under responsibility of the Universiti Teknologi MARA Sarawak
doi:10.1016/j.sbspro.2016.05.448

Nevertheless, this unpredictability can be significantly informative for investors in the financial market when the markets are working well. Hence, in this instance, it is very meaningful to capture the noise movements in the form of stock price changes (Gatheral, 2006; Abidin, Banchit, Lou & Niu, 2013). The motivation of this paper are, firstly the outcome of this research could benefit both the financial industry in New Zealand (NZ) as well as enhance the research area pertaining to the behaviour of extreme noise movements of heavily trading stock returns. Secondly, this paper aims to provide a deeper understanding of the market volatility in New Zealand during the recent financial crisis as this could help to minimize risks associated with future financial crises.

Previous studies have shown that financial markets reveal a striking feature of noise price movement which comprises two distinct components (Giot, Laurent & Petitjean, 2010). Regular noise, the first component represents noise that is frequent but does not bring any abrupt changes. The second component known as price jumps seldom occurs but signifies price movements. Price jumps do not fit into the description of the first noise component and thus have to be treated on their own (Merton, 1976) and sometimes can be difficult to interpret (Pan, 2002; Broadie & Jain, 2008).

The goal of this research paper is essentially to address two questions. First, it seeks to determine whether the overall market volatility in New Zealand increases when the GFC2008 occurs. Second, it aims to determine whether the behaviour of price jumps changes significantly during the recent crisis. The methods employed by Novotny (2010) and Hanousek, Kočenda and Novotny (2014) are adapted in the NZ setting by selecting 10 highly traded shares and one Exchange Traded Fund (ETF) from the NZ exchanges found in the Yahoo Finance and NZX50 database. All these shares represent important portion of the traded financial assets. The time period of data spanned from January 2008 to July 2009. It is found that the overall volatility dramatically scaled up in September 2008 when the Lehman Brothers in the United States (US) filed for Chapter 11 bankruptcy protection. In addition, the period immediately after this announcement reveals significantly higher levels of price volatility. However, the results do not show any significant changes on the ratio between the regular noise and price jump components of volatility during the crisis to draw any industry-dependent conclusions. This result is consistent with Novotny (2010) and Hanousek et al., (2014) suggesting that the individual firm's behaviour increases as well as decreases soon after an event.

2. Literature review

Previous research provides a wide range of explanations on classifying volatility. Harris (2003) discusses the volatility from the financial practitioners' viewpoint where the most important perspective is to separate the Gaussian-like component from price jumps. This separation can be seen in the first pioneering papers dealing with price jumps (Merton, 1976; Gatheral, 2006). Recently, the same point was also argued by Giot, Laurent and Petitjean (2010) on the division in the Gaussian-like component and price jumps. The motivation for this separation is purely mathematical; however, it is also meaningful as it can be exploited within the realms of financial market behaviour.

Price jumps is a phenomena of abrupt price changes over a very short time. It is related to a broad range of market occurrence that cannot be connected to the noisy Gaussian distribution. Price jumps also have the ability to signal changes in the market or a part of the market. Hence, the price jumps phenomenon may react as a proxy for these moments to study market efficiency (Fama, 1970) or information-driven trading (Cornell & Sirri, 1992; Kennedy, Sivakamur & Vetzal, 2006). Financial regulators may use this knowledge to implement the most optimal policies (Becketti & Roberts, 1990; Tinic, 1995) or estimate the performance of various financial vehicles (Heston, 1993; Bates, 1996; Scott, 1997; Gatheral, 2006). Most recently, by robustly testing the U.S. and the European markets, Novotny (2010) and Hanousek et al., (2014) found the overall volatility scaled up especially for the recent financial crisis but the structure of the volatility seems not to change much.

Two main conclusions are found on the causes of price jumps. The first argument by Bouchaud and Potters (2004) and Joulin et al. (2008) states that lack of liquidity available in the market though high volume of trading occurs or what they call relative liquidity is the main source of price jumps. In fact, they claim that the effect of news announcements will not affect the jumpiness of price jumps. While the second opinion by Lahaye, Laurent and Neely (2009) conjure that the news announcements are a significant source of price jumps. They also show a connection between macroeconomic announcements and price jumps on developed markets.

Price jumps shown by abrupt price movement can be much larger when compared to today's market situation. Hence, the definition of price jumps that fulfil the intuitive definition can be best represented by the most frequent approach in the literature which is based on the assumption that the price of asset *St* follows stochastic differential equation. The two parts contributing to volatility are regular noise and price jumps (Merton, 1976):

$$dSt = \mu tdt + \sigma tdWt + YtdJt \tag{1}$$

where μt means a deterministic trend, σt represents time-dependent volatility, *dWt* means standard Brownian motion and *YtdJt* corresponds to the Poisson-like jump process. The term $\sigma tdWt$ corresponds to the regular noise component, while the term *YtdJt* corresponds to price jumps. Both terms together form the volatility of the market.

3. Data

3.1. Data selection

A set of 10 categories of shares and one Exchange Traded Fund (ETF) were selected from the NZX50, Bloomberg and Yahoo Finance database. As mentioned earlier, data was collected from January 2008 till the end of July 2009. GFC2008 is represented with the fall of Lehman Brothers shares on September 9, 2008, the selected time period covers the financial crisis with the peak in September 2008. Table 1 shows the selected shares, where these shares and ETF are represented by their tickers.

Table 1. List of shares and ETF.

Id	Ticker	Name	Sector	Index/Database	Volume (31/7/2009)	Capitalisation ($NZ 000s)
1	TLS	Telstra Corp.	Overseas	NZX50/Yahoofinance	1,609,578	63,708,541.00
2	CEN	Contact Energy Ltd.	Energy	NZX50/Yahoofinance	138,325	3,967,163.00
3	AIA	Auckland International Airport Ltd.	Service/Ports	NZX50/Yahoofinance	598,780	3,524,634.00
	FBU	Fletcher Building Ltd.	Primary/Building	NZX50/Yahoofinance	253,686	5,046,928.00
5	FPH	Fisher & Paykel Healthcare Co.	Goods/Intermed & Durables	NZX50/Yahoofinance	265,949	1,275,287.00
6	IFT	Infratil Ltd.	Energy	NZX50/Yahoofinance	23,599	1,273,650.00
7	RYM	Ryman Healthcare Ltd.	Finance	NZX50/Yahoofinance	75,358	2,060,000.00
8	SKC	SKYCITY Entertainment Group Ltd.	Leisure & Tourism	NZX50/Yahoofinance	255,938	2,198,211.00
9	SKT	Sky Network Television Ltd.	Media & Comms	NZX50/Yahoofinance	1,015,324	1,965,156.00
10	TNZ NZ	smartTENZ	ETF	NZX50/Yahoofinance	209,197	3,967,163.00
11	TEL	Telecom Corporation of New Zealand Ltd.	Media & Comms	NZX50/Yahoofinance	3,025,200	4,454,635.00

The shares employed in this research accord to the following criteria. First, all the shares involve high trading volumes of stock flow to accord to homogenous time series data. Second, the samples selected for this research involve high market importance. One of the most general ways of judging market importance is the market capitalization of the company and its inclusion into the main stock market indices that are a substantial part of the NZX50 index.

Moreover, NZX50 is considered to represent the benchmark of the industrial performance of the NZ economy. Thus, tracking the select companies with a large weight in NZX50 equals to track changes in NZ industrial performance. All these 10 shares are chosen from different sectors amongst different industries. Therefore, the sample can m more effectively reflect the overall economic environment of New Zealand.

Finally, an ETF is included in the sample. It tracks the NZX10 index performance. This ETF is very popular and highly traded for those who want to track the NZX10 index performance as a whole. This ETF is another perspective of benchmark for NZ economy.

3.2. Sample sub-periods definition

The main purpose of the paper is to examine whether there are any changes in the price jump behaviour in NZ's financial markets caused by GFC 2008. The entire sample was divided into sub-samples corresponding to different sub-periods. The number of price jumps or the degree for jumpiness was also tested for each trading day. Comparison of the statistics of two sub-periods was then done; the financial crisis period and non-financial (before) crisis period.

As there is no standard date declared as the beginning of the crisis, this paper uses the start of the GFC2008 which is September 9, 2008, the day the shares of Lehman Brothers plunged, of which this is also consistent with Novotny (2010). Based on this special event, the date of September 9, 2008 is set as a point of structural break in the behaviour of financial markets. Therefore, we employ two different versions of the breaking scheme:

- The Permanent Break (PB): The crisis started on September 9, 2008 and lasted until the end of the sample.
- The Temporary Break (TB): The crisis started on September 9, 2008 and lasted 30 trading days, which equals to 1.5 months. The period of 30 working days was chosen based on the news and the behaviour of financial markets.

4. Methodology

In this paper three methods are employed to address the research questions and test the behaviour of price jumps.

4.1. Extreme returns

Price jumps are basically accepted as returns with very low or very high numbers. Therefore, the definition of extreme returns to test the price jump can be represented as follows: assume a price jump at time *t,* if the return on it at time *t* is above some threshold it is the extreme return. There are commonly two approaches to select the value of threshold. First, it can be selected globally and used as the threshold for the entire sample. Second, it can be selected locally, in which, the threshold values are determined for each sub-samples. As we are considering only the NZ market, we shall adopt the second approach for this study. Thus, the results will not be affected by comparing price jumps over periods with different market conditions.

To be specific, there are three versions to process the extreme return. First, the absolute returns are defined as $|r_T|$. This means at time T the price jump happened and if this absolute return is over the $(100 - X)$ % distribution of the entire sample it is defined as extreme return. Second, the absolute returns are defined as $|r_T - < r_T > s|$, where $< >$S is denoted as the mean taken over the entire sample. This means at time T the price jump happened and if this absolute return is over the $(100 - X)$ % distribution of the entire sample it is defined as extreme return. Third, the absolute returns are not dependent on any distribution. This means at time T the price jump happened and if this absolute return is over the $(100 - X)$ % or below X / 2 % of the entire sample it is defined as extreme return.

4.2. Temperature

It has been proven that for the S&P 500 and the NASDAQ 100 indices, the property that they have is purely an exponential behaviour for both the positive and negative sides of the distribution; the distribution can fit the Boltzmann distribution (Kleinert, 2009). Novotny (2010) employs this approach as he used the same index as

Kleinert et al., (2009) who used S&P 500. As for the share index which is NZX50, by computing log return, we consider the shares return as also following Boltzmann distribution[1] prompting us to adopt this approach in our paper.

$$B(r) = \left(\frac{1}{2T}\right) \exp\left(\frac{|r|}{T}\right) \tag{2}$$

where *T* denotes the parameter of the distribution, which is commonly recognised as the temperature, and *r* denotes returns. The distribution is assumed to be symmetrically centred on zero. The parameter *T* is the distribution width; the higher the temperature of the market, the higher the volatility. This is consistent with Silva, Prange and Yakovenko (2004); Kleinert and Chen (2007); Kleinert (2009) who state that this parameter will change slowly, and its variation is highly related to the situation on the market.

4.3. Dependent realized volatility

Realized volatility can be computed in a standard approach as the second centred moment within an existing sample. This equation represents a particular situation in the general *p*-dependent realized volatility definition:

$$pR\,V_T^p(t) = \left(\sum_{\tau=t-T+1}^{t} |r_\tau|^p\right)^{1/p} \tag{3}$$

The moving window of length T is computed for the sample over which the volatility (Dacorogna, 2001). The more price jumps are stressed, the higher the *p* will be. Basically, an estimator of price jumps is used for the ratio between two realized volatilities with different *p*-value.

4.4. Hypotheses testing

To better test the issue introduced at the start of this research, a null hypothesis is employed. To be specific, the *p*-dependent realized volatility model tests the financial markets jumpiness upon daily basis. It evaluates the jumpiness of each tick. Based on this, the measure of daily jumpiness is obtained. We compute variance and mean of these numbers for each trading day (one number for each). Meanwhile, we divide the sample into two sub-samples (non-crisis period, crisis period).

Hypothesis 1: The null hypothesis for the first test is that the structure of price jump behaviour for the financial crisis period is the same as the non-financial period. The daily means of the two sub-samples originally come from one distribution. The purpose of the test is to determine whether there is any change in the structure of the estimated price jump during the crisis period.

Hypothesis 2: The null hypothesis testing process is the same as Hypothesis 1 while the variance will replace the mean for testing data.

5. Empirical results

5.1. Extreme returns

Figures 1 and 2 suggest that the extreme returns increased sharply after September 9, 2008 (shown by the number of trading days at 253rd day of the year). It suggests an increased phenomena happening on market volatility. Additionally, after the event of Lehman Brothers, the turbulence also happened in the beginning of 2009, when the

[1] "Boltzmann distribution law, which tells us with what frequency the individual microscopic states of a system of given temperature occur" (Widom, 2004, p.1).

extreme returns also scaled up. However, this cannot directly respond to the ratio of price jump increase over this period as extreme movements are much higher compared to the current market situation.

5.2. Temperature

Figure 3 reveals the estimated temperature for each stock computed based on daily data. The temperature model is the same as the extreme return model in that both are not able to distinguish price jumps. Thus, these statistical results support the conclusion made by the previous extreme return model that for the period following Lehman Brothers' event, market volatility increased dramatically.

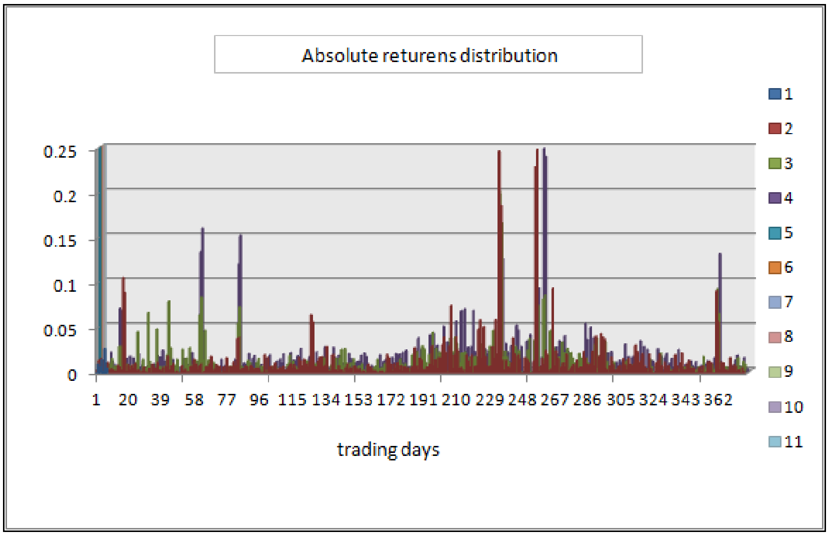

Fig. 1. Absolute return distributions.

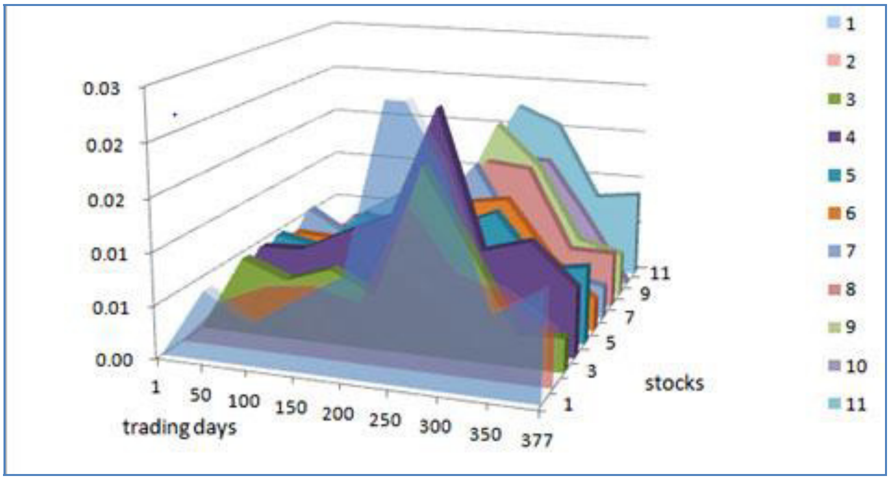

Fig. 2. Price jumps based on absolute return.

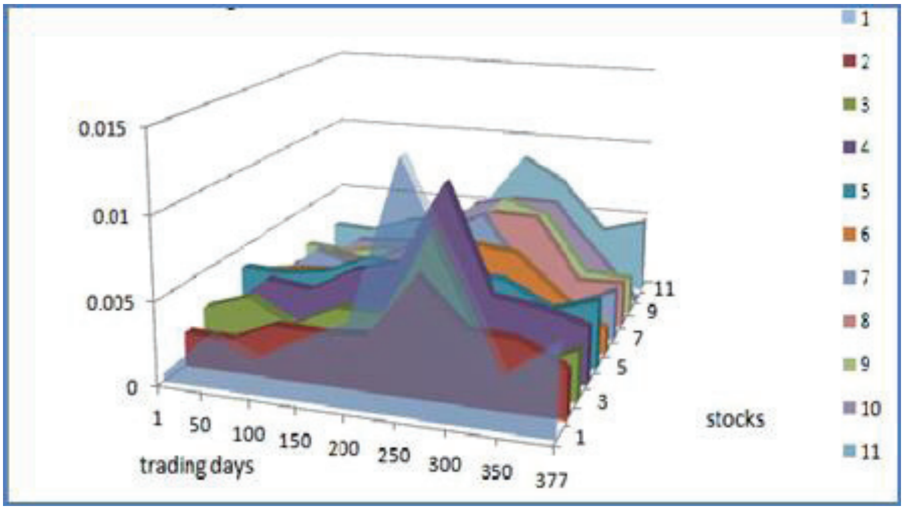

Fig. 3. Price jump based on extreme returns.

5.3. p-dependent realized volatility

Hypothesis 1: Table 2 shows the result for Wilcoxon statistics for this hypothesis. The numbers are *z*-value by comparing two sub-samples (crisis period and non-crisis period). The stars behind each value imply the significance level to reject the null hypothesis. Additionally, among all these z-values the excessively high numbers imply a situation that the median of means outside the crisis is larger than the median of means during the crisis. The low *z*-values indicate the other way.

For example, in the case of firm TLS with $T = 60$ under the assumption that the crisis is a permanent break, the *z*-value equals to −3.232, which means that at 99% confidence level, the null hypothesis can be rejected. Additionally, this negative number implies that the median of means before the emergence of Lehman Brothers' failure is lower comparing with the previous period. This means that TLS shares tend to be more jumpy during the crisis rather than non-crisis period.

Table 2. Results of two-sample Wilcoxon test for the mean $pRV_{T}^{p/p'}$ (t).

Id	Ticker	Permanent Break		Temporary Break	
		60	120	60	120
1	TLS	-3.232***	-4.254***	1.089*	0.814
2	CEN	4.385***	3.194***	-0108	-1.502
3	AIA	-3.21***	-0.738***	0.187	0.781
4	FBU	5.962***	4.868***	1.642	1.062
5	FPH	2.435**	0.081	1.291	-0.097
6	IFT	-1.859***	-0.439***	0.402	0.856
7	RYM	5.148***	4.096***	0.893	0.652
8	SKC	4.986	3.665	2.994***	2.941**
9	SKT	1.367*	1.031	0.216	0.136
10	TNZ NZ	4.169***	3.507***	-0.053	0.044
11	TEL	5.743***	4.836***	-3.688***	-3.269***

From the overall perspective, the mean of z-value reveals that when the financial crisis is assumed as the Permanent Break, the mean distributions are aggressively different. This means that the crisis emerged in the subsequent period no matter how unstable the share price is for the period after the event. Moreover, most *z*-values tend to be positive. This suggests that the median of means for the *p*-ratio is higher during the non-crisis period where it implies that within the entire volatility the ratio of price jumps component decreased during the crisis. This result is consistent with Novotny (2010) which employed the same model on the U.S. market. For Hypothesis 2, the results of the Wilcoxon test with variance are shown in Table 3. Overall, the results are similar as previous test. Both the shares and the price jump ratios tend to have significantly different distributions of the estimated variances. Additionally, for the case of Temporary Break the null hypothesis cannot be rejected about the agreement on the variance distributions during the entire period.

Table 3: Results of two-sample Wilcoxon test for the variance $pRV_T^{P/D'}$ (t).

Id	Ticker	Permanent Break		Temporary Break	
		60	120	60	120
1	TLS	-4.273***	-4.254***	1.206*	0.645
2	CEN	5.946**	3.194**	-0.261	-0.032
3	AIA	1.497	-0.738	1.067	0.614
4	FBU	4.526***	0.359***	0.958	0.089
5	FPH	2.096**	1.077	-0.149	-0.056
6	IFT	-1859	-0.439	0.402	0.128
7	RYM	4.282***	3.982***	0.893	0.267
8	SKC	2.013	1.723	-0.526	-0.193
9	SKT	1.029	0.492	0.198	0.085
10	TNZ NZ	4.487***	3.046***	-0.107	0.023
11	TEL	5.036***	4.527***	-2.688**	-2.013*

6. Conclusions

This paper is a technical analysis of price jumps utilising 10 major traded shares and one ETF traded on the main New Zealand exchanges. The data range spans from the beginning of January 2008 till the end of July 2009. This paper attempts to identify the problem of whether price jump behaviour, defined by the nature of volatility from regular Gaussian noise, is different during the financial crisis period compared to non-crisis period.

The results reveal that the overall volatility soars during the financial crisis especially following the announcement of Lehman Brothers issue. The volatility level keeps rising until October 2009. Nevertheless, it was still higher than the non-crisis level. For the first three months of 2009, the volatility level sharply rises again. In the first two months of 2009, the volatility increases again, mainly for the banking industry. However, this result did not show that the price jumps had increased during the crisis period.

The nature of price jumps is that a high level of price jumps implies a high rate of market turbulence involving more irrational activities. On the other hand, a comparative lower rate of price jumps implies the market panic level remained the same. However, among the samples selected, some cases involve high rate of price jumps while others involve relatively lower rate of price jumps during the crisis. Additionally, it is difficult to draw any conclusion from the industry-dependent level. Finally, the paper proves Novotny's theory that different models can provide very different results in measuring the price jumps. The differences in sensitivity can be very difficult to describe, which may need a more comprehensive numerical analysis. If the relationship among the price jump indicators employed can be determined, we may be able to generate more accurate results on price jump behaviours. This confirms the similarity in behaviour between the developed markets of the US and NZ. Future studies will entail using data from developing markets such as the ASEAN market to determine whether share market behaviour does act differently.

References

Abidin, S., Banchit, A., Lou, R., & Niu, Q. (2013). Information flow and causality between price change and trading volume in silver and platinum futures contracts. *International Journal of Economics, Finance and Management, 2*(2), 241-249.

Bates, D. (1996). Jump and stochastic volatility: Exchange rate processes implicit in deutche mark in options. *Review of Financial Studies, 9*(1), 69-107.

Becketti, S., & Roberts, D. J. (1990). Will increased regulation of stock index futures reduce stock market volatility? *Economic Review*, *Federal Reserve Bank of Kansas City,* (November Issue), 33-46.

Bouchaud, J-P., & Potters, M. (2003). *Theory of financial risk and derivative pricing: From statistical physics to risk management* (2nd ed.). United Kingdom: Cambridge University Press.

Broadie, M., & Jain, A. (2008). The effect of jumps and discrete sampling on volatility and variance swaps. *International Journal of Theoretical and Applied Finance, 11*(8), 761-797.

Cornell, B., & Sirri, E. R. (1992). The reaction of investors and stock prices to insider trading. *Journal of Finance, 47*(3), 1031-1060.

Dacorogna, M. M. (2001). *An introduction to high-frequency finance.* San Diego: Academic Press.

Fama, E. (1970). Efficient capital markets: A review of theory and empirical work. *Journal of Finance, 25,* 383-417.

Gatheral, J. (2006). *Volatility surface: A practitioner's guide*. New Jersey: John Wiley & Sons, Inc.

Giot, P., Laurent, S., & Petitjean, M. (2010). Trading activity, realized volatility and jumps. *Journal of Empirical Finance, 17,* 168-175.

Harris, L. (2003). *Trading and exchanges: Market microstructure for practitioners.* New York: Oxford University Press.

Heston, S. L. (1993). A closed-form solution for options with stochastic volatility with applications to bond and currency options. T*he Review of Financial Studies, 6*(2), 327-343.

Joulin, A., Lefevre, A., Grunberg, D., & Bouchaud, J. P. (2008). Stock price jumps: News and volume play a minor role. *arXiv preprint arXiv:0803.1769*.

Kennedy, D. B., Sivakumar, R., & Vetzal, K. R. (2006). The implications of IPO under pricing for the firm and insiders: Tests of asymmetric information theories. *Journal of Empirical Finance, 13*(1), 49-78.

Kleinert, H. (2009). *Path integrals in quantum mechanics, statistics, polymer physics, and financial market* (5th ed.). Berlin: World Scientific.

Kleinert, H., & Chen, X. J. (2007). Boltzmann distribution and market temperature. *Physica A, 383*(2), 513-518.

Lahaye, J., Laurent, S., & Neely, C. J. (2009). *Jumps, cojumps and macro announcements.* Working Paper of Federal Reserve Bank of St. Louis, No 2007-032, Revised Version.

Mann, H. B., & Whitney, D. R. (1947). On a test of whether one of two random variables is stochastically larger than the other. A*nnals of Mathematical Statistics, 18,* 50-60.

Merton, R. C. (1976). Option pricing when underlying stock returns are discontinuous. *Journal of Financial Economics, 3*(1-2), 125-144.

Novotny, J. (2010). *Were stocks during the financial crisis more jumpy: A comparative study?* CERGE – EI. Working Paper Series 416.

Hanousek, J., Kočenda, E., & Novotny, J. (2014). Price jumps on European stock markets. *Borsa Istanbul Review*, *14*(1), 10-22.

Pan, J. (2002). The jump-risk premia implicit in options: Evidence from an integrated time-series study. *Journal of Financial Economics, 63,* 3-50.

Scott, L. (1997). Pricing stock options in a jump-diffusion model with stochastic volatility and interest rates: Applications of fourier inversion methods. *Mathematical Finance, 7*(4), 413-424.

Silva, A. C., Prange, R. E., & Yakovenko, V. M. (2004). Exponential distribution of financial returns at mesoscopic time lags: A new stylized fact. *Physica A, 344*(1-2), 227-235.

Tinic, S. M. (1995). Derivatives and stock market volatility: Is additional government regulation necessary? *Journal of Financial Services Research,* 9(3-4), 351-362.

Widom, B. (2004). *The Boltzmann distribution law and statistical thermodynamics*. Cambridge: Cambridge University Press.

Wilcoxon, F. (1945). Individual comparisons by ranking methods. *Biometrics, 1,* 80-83.